AN OPEN ARCHITECTURE APPROACH TO
NETWORK ENABLED CAPABILITY

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Abstract

Research in the UK is currently being conducted to develop an open architecture solution for Network Enabled Capability (NEC). This paper outlines the current status of that research and discusses some key architectural issues.

1 Introduction

Whilst in other warfare areas (e.g. air defence) significant steps have been made towards the development of a Network Enabled Capability (NEC), for the past 30 years the SSN has assumed an independent and covert operational role - hence connectivity and inter-operability have not been at the forefront of the military requirements.

In addition, the submarine was not required to fuse underwater and above water data in order to populate a Common Underwater Picture (CUP) or contribute to a higher level Common Operating Picture (COP). Thus the SSN has not been network enabled to any great degree and lack of integration within the underwater battlespace and insufficient ability to exchange information across global ISTAR assets has led to generally poor situational awareness.

Following the success of the concepts behind the US Network Centric Warfare (NCW) programme, as demonstrated in the Afghanistan, Bosnia, and Iraq conflicts, Network Enabled Capability has come to be regarded as critical to the next generation of UK equipment capabilities.

This paper presents the status of current research in the UK to develop a Network Enabled Capability for the underwater battlespace based on two parallel threads of investigation:
- The development of an **Advanced Picture Compilation** capability for improved operability
- The development of **An NEC Infrastructure** for interconnectivity between platforms and information management

This work builds on and continues the very successful DeRSCI Open Architectures initiative in the UK. This has successfully demonstrated open systems design and the use of COTS technology to enable rapid capability upgrades through incremental acquisition and to reduce the impact of obsolescence. The DeRSCI project has defined a Generic Open Architecture (GOA) for submarine sonar and command system design. DeRSCI is committed to the demonstration of a rapidly evolving capability in a series of Technology Demonstrators (TDs) at sea, connected to real equipments and used by RN staff.

Both the GOA and the pragmatic TD approach will be extended into the NEC arena.

This paper has three subsidiary sections:
- **Section 2** presents some architectural issues related to advanced picture compilation

- **Section 3** describes current ideas for an NEC infrastructure
- **Section 4** discusses the measurement of improved situational awareness

2 Advanced Picture Compilation

The tasks of picture compilation, and thus achieving and maintaining situational awareness, are very manually intensive with the current combat systems available. With NEC, the increase in information volume and complexity and the future requirement for reduced manning levels will only aggravate this problem and thus operator aids and increased automation will be essential features of a Common Underwater Picture capability.

In order to provide this capability a number of key advances are required:

- The various types of information must be made available to the operator within a common Human Computer Interface and in an accessible and intuitive format
- Tools must be provided to the operator to enable the manipulation of this information. This will include (but is not limited to) tools for filtering, overlaying, and associating the data. These tools will reduce the time it takes for an operator to compile and maintain a Common Underwater Picture, and will support easier understanding of how the different types of data relate to each other
- Automated (both semi-automatic and fully automatic) picture management algorithms including data fusion, classification and various kinds of tactical decision aids will be needed to assist the operator in compiling and maintaining a Common Underwater Picture

An architectural framework for NEC picture compilation is under development that is specifically geared to ease the integration of third party components.

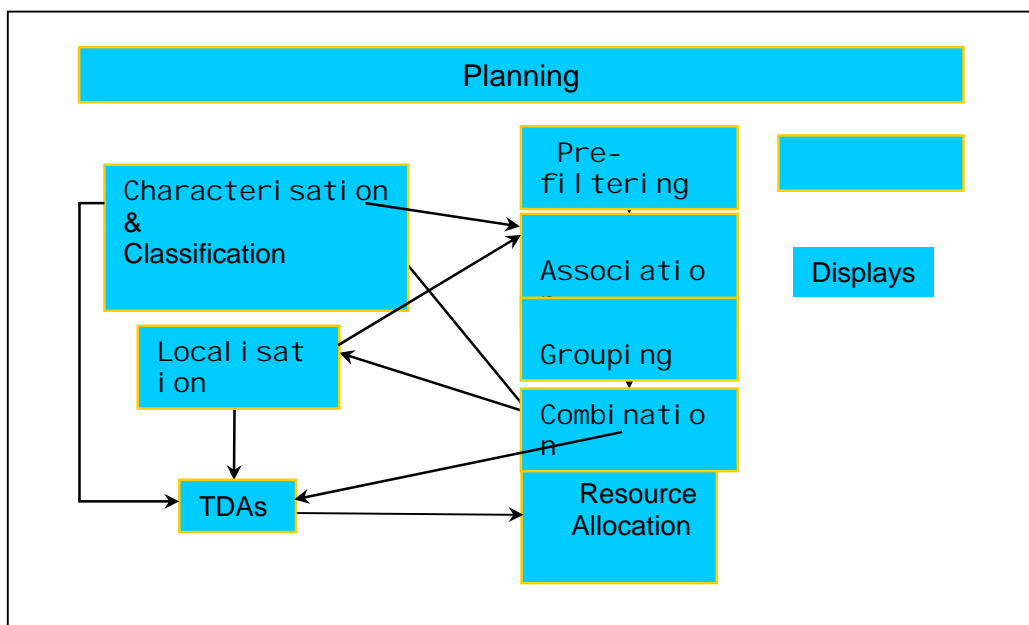The framework is based on the scheme shown in Figure 1.

Figure 1 Picture Compilation Architectural Concept

The boxes on the diagram are:

- Pre-filtering: The filtering or processing of sensor track data. For example, smoothing and outlier rejection, which smoothes and removes outliers from track data

- Association: The calculation of the usefulness of candidate groupings of stored tracks. Association in NEC tends to produce a probability of association between tracks

- Grouping: This is the second stage of association, and groups tracks together in an optimal manner. The grouper uses the probabilities generated by association as an input

- Combination: A process after association and grouping that uses composite tracks to create some sort of improved estimate of the properties of real world objects. This will usually involve data reduction and often improved localisation, but also possible benefits such as estimates of speed, direction, uncertainty areas, classification, intent, threat etc

- Localisation: Localisation overlaps to some extent with combination, but can work with just one sensor track and hence does no fusion, association or combination. In this development plan localisation is intended to mean localisation that is not combination

- TDAs and Planning: Tactical Decision Aids and planning. For example a TMA manoeuvre advisor that gives advice on the manoeuvre required to obtain a better solution

- Resource Allocation: Algorithms for allocating resources, such as people, computing resources, sensors etc. For example sensor cueing automatically cues sensors based upon external logic

- Characterisation and Classification algorithms: Algorithms that provide classification and characterisation of targets

- Displays: GUIs and visual displays.

The architecture will be implemented using a componentised approach and the inter-component messaging will via XML defined in an XML schema.

3 An NEC Infrastructure

An NEC infrastructure, in effect, extends the capabilities of the Network Enabled Platform beyond the confines of the submarine by addressing two key functions:

- Interconnectivity – the capability to freely transport information between a diverse set of NEC assets e.g. submarines, surface ships, shore facilities, remote sensors, etc

- Information management – the capability to store and manage the information required for a Common Underwater Picture, in an efficient manner, in particular handling stale and/or conflicting information

Historically the limitations of submarine communication systems have meant that the operations in the underwater warfare domain have been largely platform centric. However recent and forthcoming advances in submarine communication systems are able to significantly extend its reach and influence.

But these developments alone cannot deliver a network enabled capability for the underwater battlespace. A network management infrastructure is required that utilises these communication systems to support the interaction required between the various elements of the force.

An architecture for NEC interconnectivity is being researched that encompasses key aspects of quality of service, session management, the configuration of communications equipments and the embodiment of necessary security practices. The architecture will be applicable to both electromagnetic and acoustic communications. By design, the architecture will be able to incorporate third party components and to permit a range of practical information management strategies to be used, as required, for communicating between a variety of NEC platforms both within UK forces and with allies.

A key aspect of this architecture is the storage and serving of track-related information on the platform in a manner that permits the straightforward development of flexible access mechanisms. These need to support both user display and manipulation and algorithmic intervention, coupled with handling of many different types of data import and export to from the outside world. The evolving Open Architecture Track Information Server (OATIS) will provide this information management facility. A full data model for OATIS is currently being defined using input from both UK industry and coalition partners. The implementations of OATIS is targeted at Oracle 10g and all inserts, queries and updates will be in the form of XML messages defined by an XML schema derived form the data model.

Security issues are central to the implementation of a viable NEC capability. The need to export information off the platform to a variety of destinations at a range of classifications places very significant constraints on the interconnectivity and the picture compilation process in general. A domain based security architecture is being developed that employs accredited virtual machines to provide improved flexibility. However, security issues are likely to remain a barrier to full and flexible exploitation of NEC concepts for the foreseeable future.

4 Measuring Improved Situational Awareness

Effective measurement of improvements to situational awareness is essential if the programme is to deliver quantifiable benefits. Metrics and assessment processes are being researched to enable this to be done.

Since situational awareness is intimately concerned with the user's ability to assimilate and manipulate picture information, these measurement processes are being integrated with a full simulation environment, based on the High Level Architecture (HLA), which will enable experiments to be conducted with naval users using realistic NEC scenarios.

An Open Architecture Approach to NEC
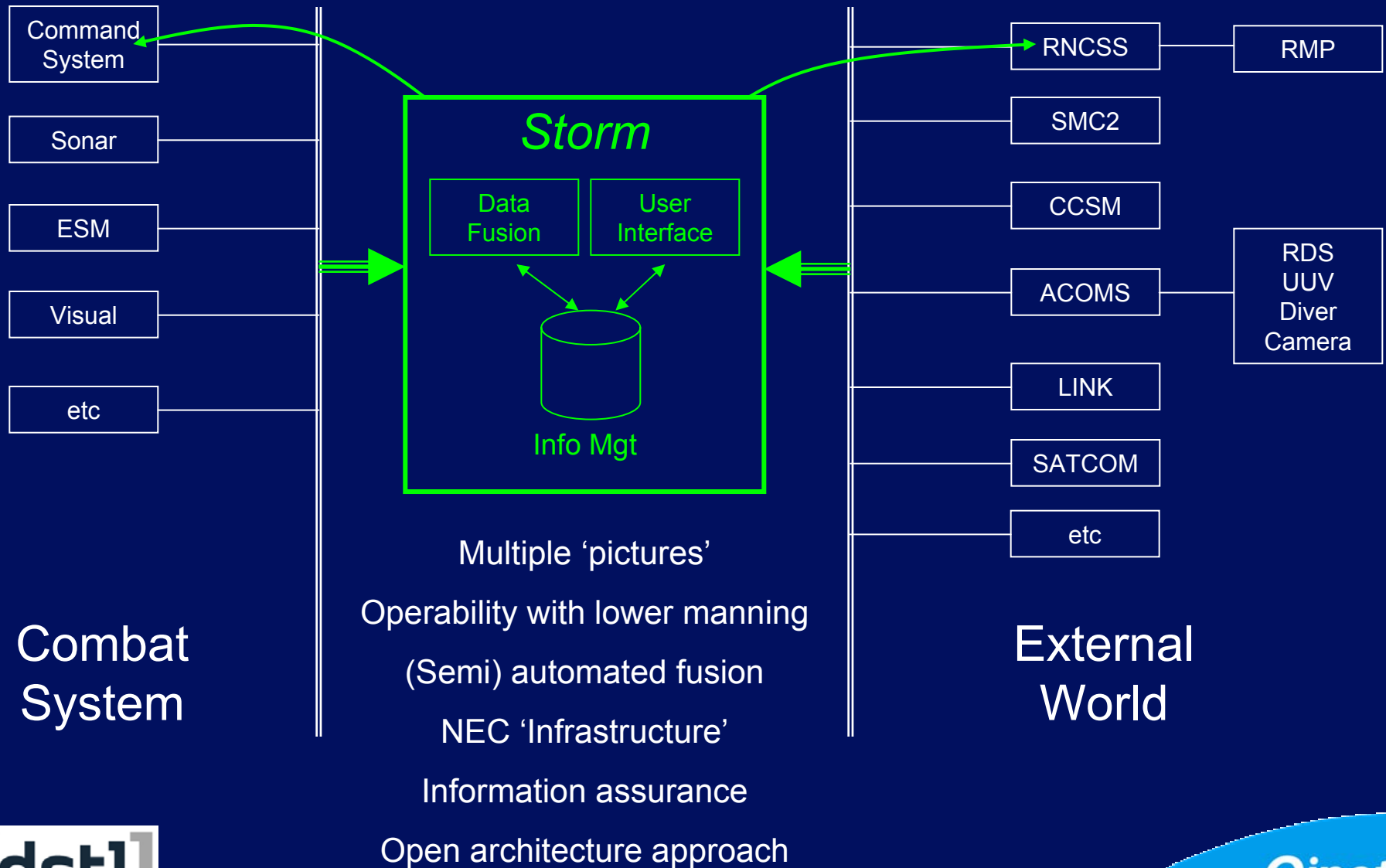
Lyn Owen - QinetiQ
Andrew Flinn - dstl

introduction

Our current research programme

"Underwater

Network Enabled Capability

Picture Compilation"

- Submarine centric but not submarine specific
- Concentrating on improved picture compilation leading to heightened situation awareness
- Largely concerned with track / tactical information
- We're building a system called *Storm* to do NEC experimentation

[dstl]

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Storm situation

Command System

Sonar

ESM

Visual

etc

Combat System

Storm

| Data Fusion | User Interface |

Info Mgt

Multiple 'pictures'

Operability with lower manning

(Semi) automated fusion

NEC 'Infrastructure'

Information assurance

Open architecture approach

RNCSS

RMP

SMC2

CCSM

ACOMS

RDS UUV Diver Camera

LINK

SATCOM

etc

External World

[dstl]

QinetiQ

Our open architecture track record

- DeRSCI research programme for UK Royal Navy

- Defined a 'Generic Open Architecture' for sonars

- Built common towed and bow sonars for a number of different arrays

- Active and intercept sonars in development

- (Almost) all COTS - hardware *and* software infrastructure

- Many successful sea trials

- Very highly regarded by MoD and RN

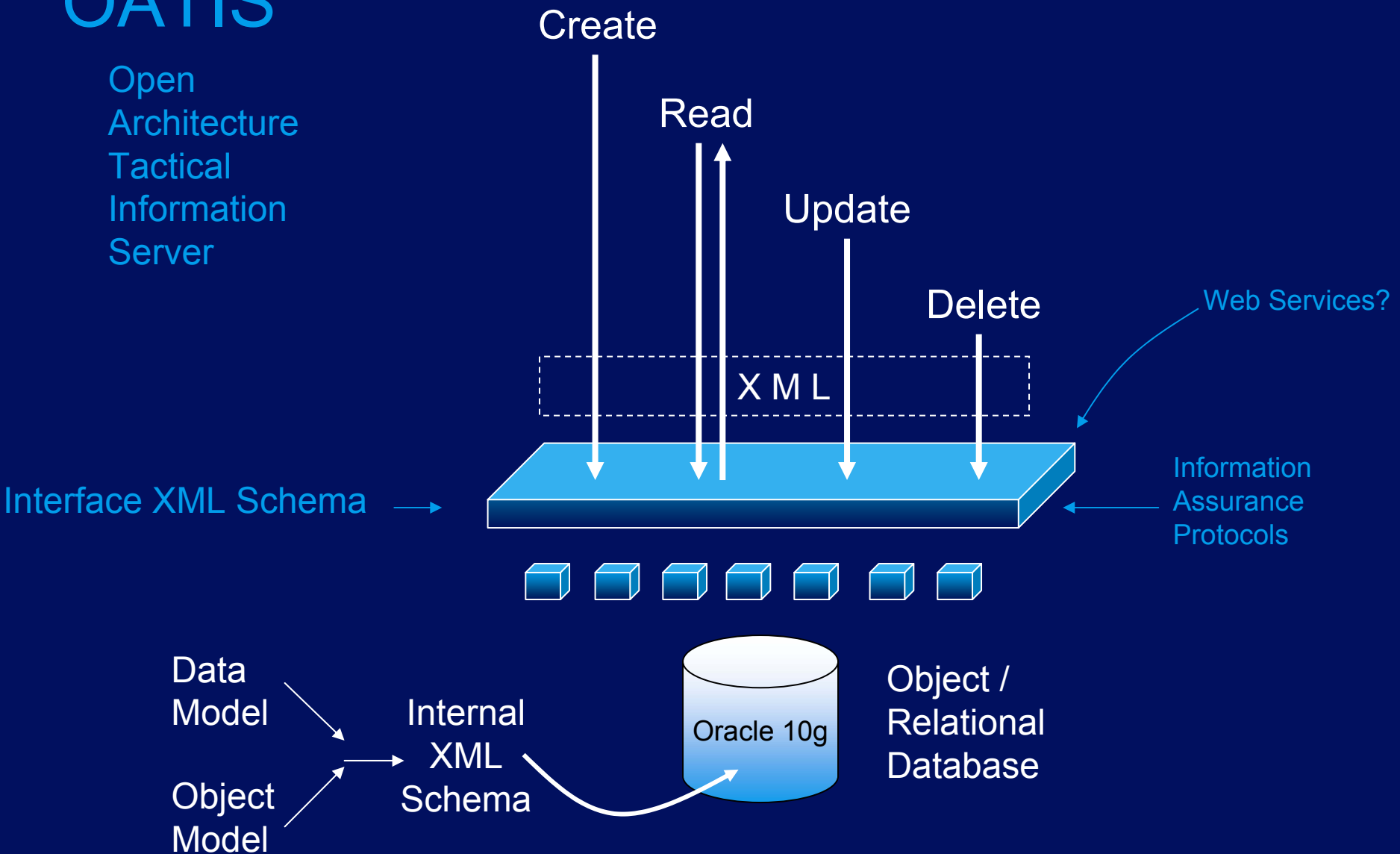- Competition for upgrading a major UK sonar about to begin

A very practical approach!

[dst1]

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Why open architectures?

- An open architecture approach *makes things easier*

- When applied to NEC, an OA approach makes it…
  - Easier to access and manage information
    - In an open but controlled manner
  - Easier to connect into the platform
    - To existing combat systems and legacy equipments
  - Easier to connect to other NEC assets
    - Using a variety of connection mechanisms
  - Easier to incorporate 3rd party components
    - Applications, sub-systems…
  - Easier to use
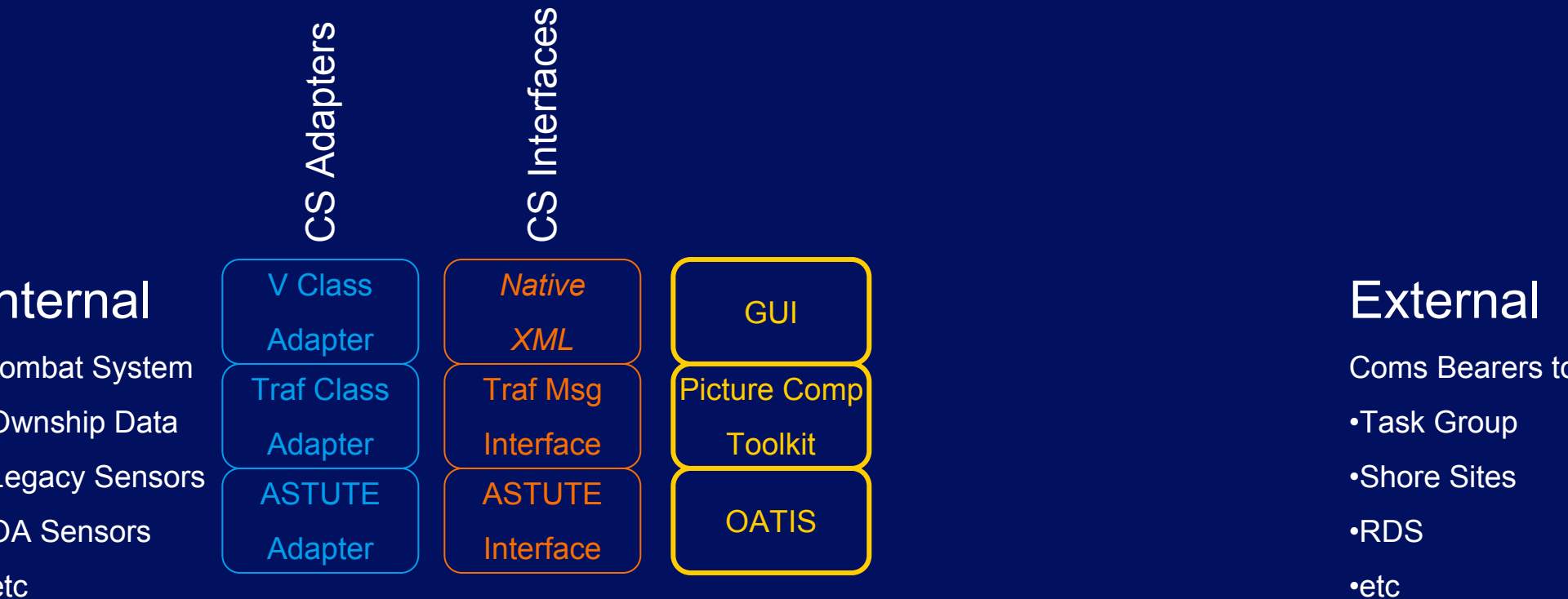   - By ordinary naval users

easier to access and manage information

OATIS

Open
Architecture
Tactical
Information
Server

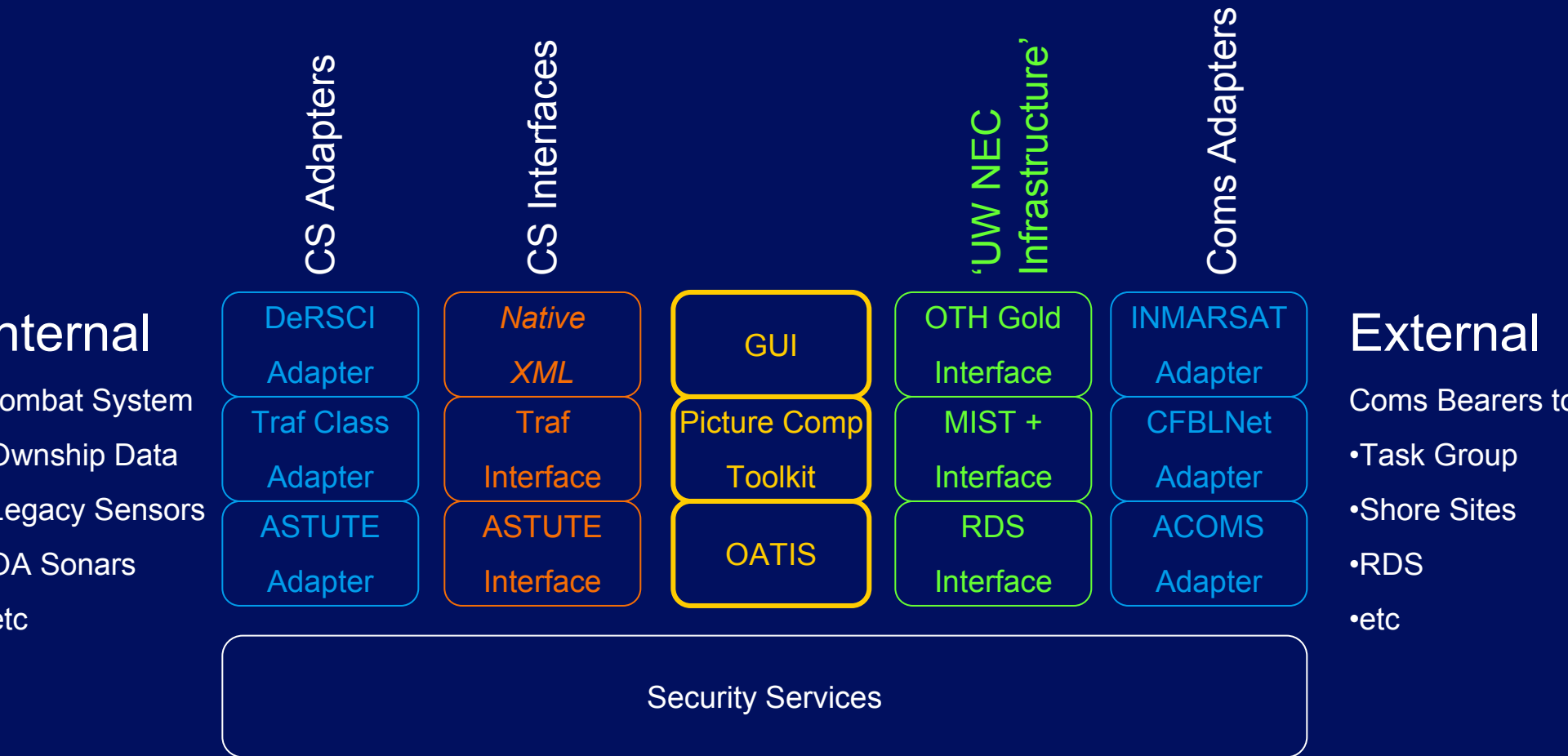Create

Read

Update

Delete

Web Services?

X M L

Interface XML Schema

Information
Assurance
Protocols

Data
Model

Object
Model

Internal
XML
Schema

Oracle 10g

Object /
Relational
Database

[dst1]

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easier to connect into the platform

Storm internal connectivity

CS Adapters

CS Interfaces

Internal

Combat System

Ownship Data

Legacy Sensors

DA Sensors

etc

| V Class Adapter |
| Traf Class Adapter |
| ASTUTE Adapter |

| *Native XML* |
| Traf Msg Interface |
| ASTUTE Interface |

| GUI |
| Picture Comp Toolkit |
| OATIS |

External

Coms Bearers to

•Task Group

•Shore Sites

•RDS

•etc

[dstl]

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easier to connect to other NEC assets

Storm external connectivity

CS Adapters

CS Interfaces

'UW NEC Infrastructure'

Coms Adapters

Internal

Combat System

Ownship Data

Legacy Sensors

DA Sonars

etc

CS Adapters	CS Interfaces		'UW NEC Infrastructure'	Coms Adapters
DeRSCI Adapter	*Native XML*	GUI	OTH Gold Interface	INMARSAT Adapter
Traf Class Adapter	Traf Interface	Picture Comp Toolkit	MIST + Interface	CFBLNet Adapter
ASTUTE Adapter	ASTUTE Interface	OATIS	RDS Interface	ACOMS Adapter

Security Services

External

Coms Bearers to

•Task Group

•Shore Sites

•RDS

•etc

[dst1]

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Problems with connecting the submarine

- Intermittent… interrupted…

- Low bandwidth now, a bit better later

- Slow adoption of IP Coms
  - But even with IP, TCP/IP may be difficult

- Often only a short time at periscope depth
  - Implies prioritisation of transfers and perhaps pull mode
  - May miss regular cyclic updates

- Sometimes covert operational role so no transmit allowed

- Short range with UHF

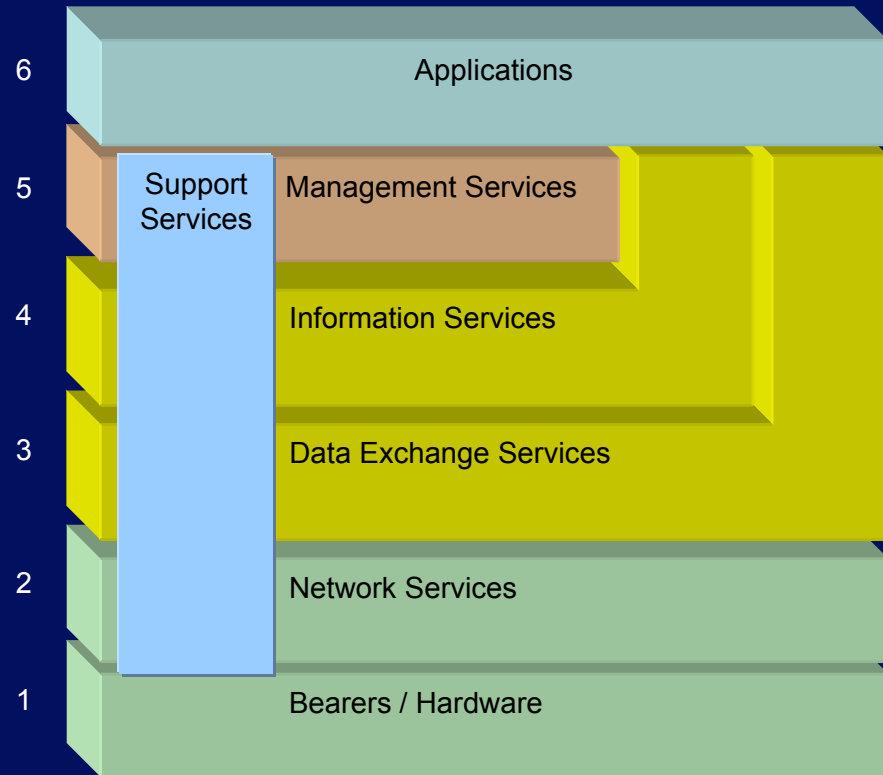- Standard surface ship mechanisms not directly suitable

Reqs for an UW NEC infrastructure

- Session management

- Quality of service

- Bandwidth optimisation
  - Push / pull
  - Information prioritisation, transfer of most important first
  - Publish / subscribe

- Information assurance / security

- Database equalisation techniques

- Covert working

Reqs for an UW NEC infrastructure

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Different mechanisms for different exchanges

[dstl]

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A model for an UW NEC infrastructure
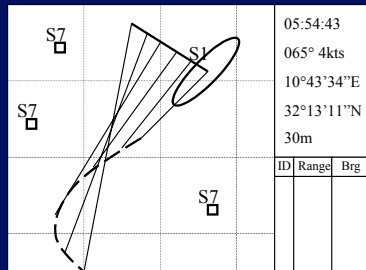
Use the model to assess candidate products and approaches

6	Applications
5	Support Services / Management Services
4	Information Services
3	Data Exchange Services
2	Network Services
1	Bearers / Hardware

easier to incorporate 3rd party components

Generic granularity + dataflow model

Manual Toolkit   **Automatics**

Associate tracks

Disassociate tracks

Make recommendation

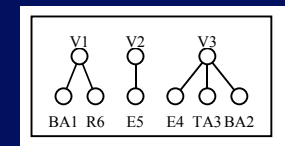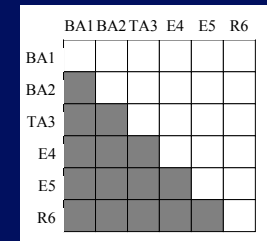Accept recommendation
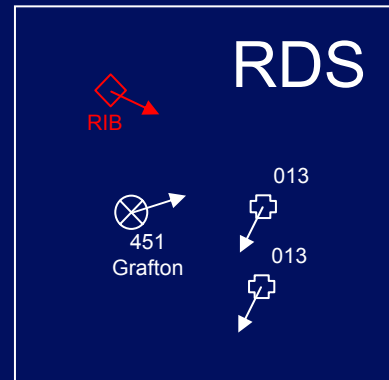
Choose combination

Association → Pairwise Weights

Grouping → Groups

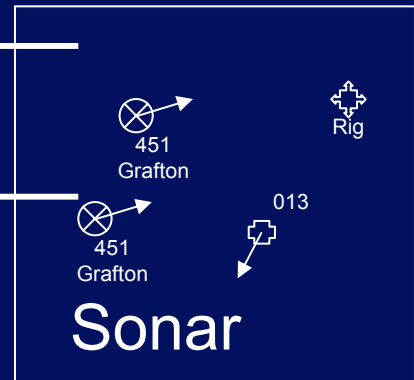Combination → Vessel Tracks

05:54:43
065° 4kts
10°43'34"E
32°13'11"N
30m

ID	Range	Brg

	BA1	BA2	TA3	E4	E5	R6
BA1						
BA2						
TA3						
E4						
E5						
R6						

Vessel	Last update	Bearing	Range
V1	10:28:32	045	10.5
V2	10:28:32	183	#
V3	10:28:04	346	5.7

dst1

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easier to use

GUI layers and tactical pictures

Link

RMP

451
Grafton

451
Grafton

013

Automatics

Sonar

451
Grafton

451
Grafton

Rig

013

RDS

RIB

451
Grafton

013

013

Best

Rig

451
Grafton

451
Grafton
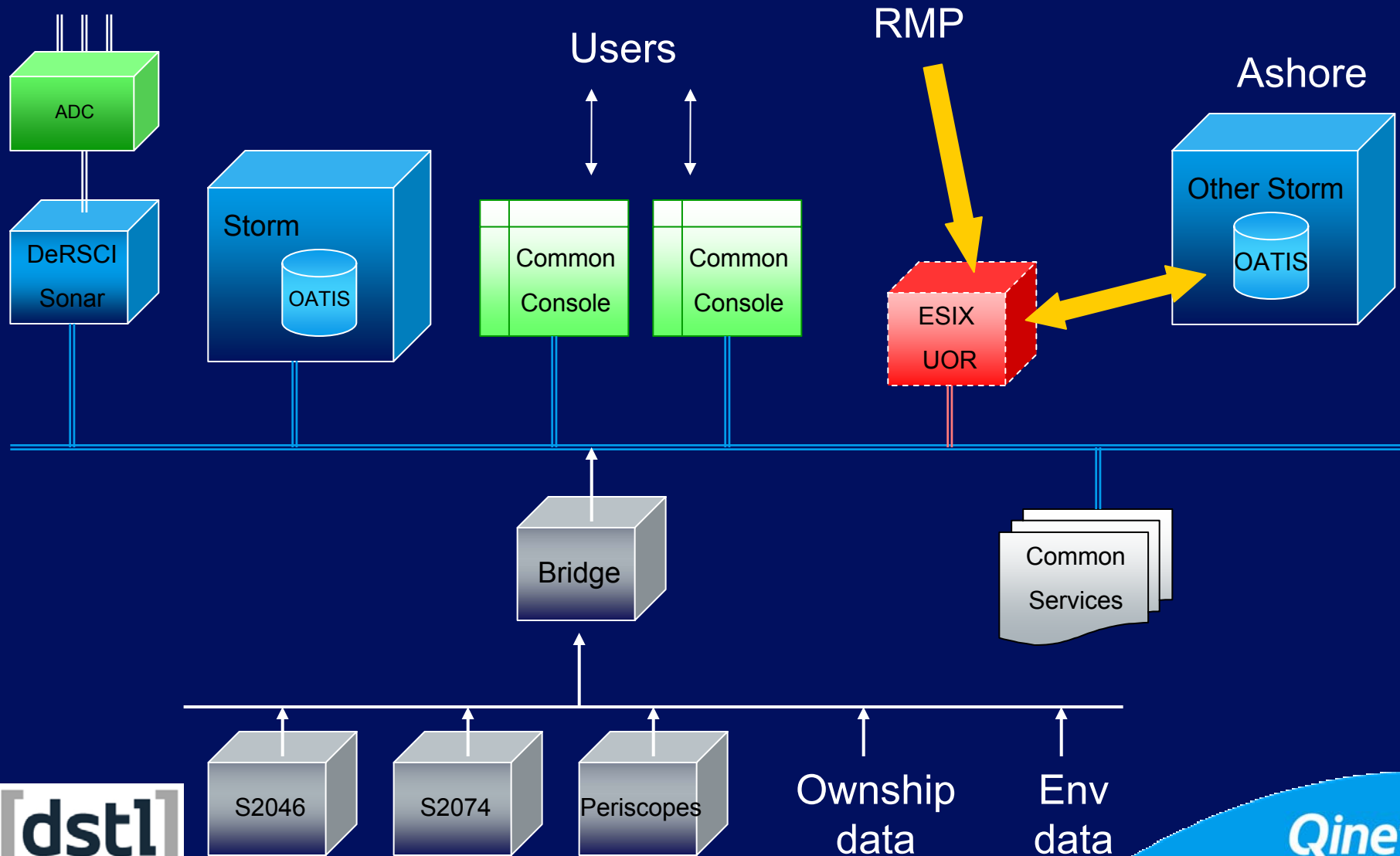
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AML/S57
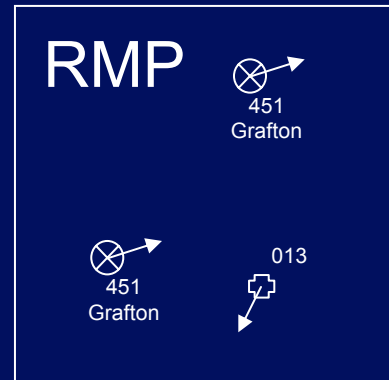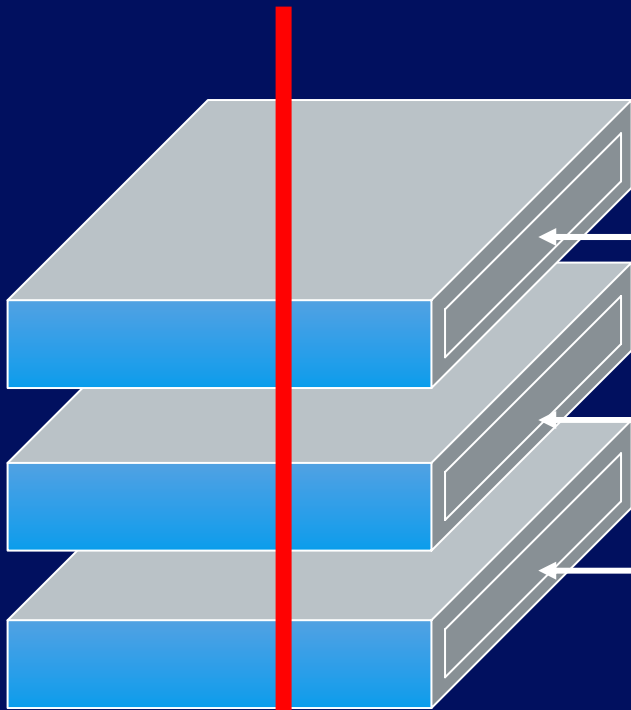
QinetiQ

Early Storm GUI
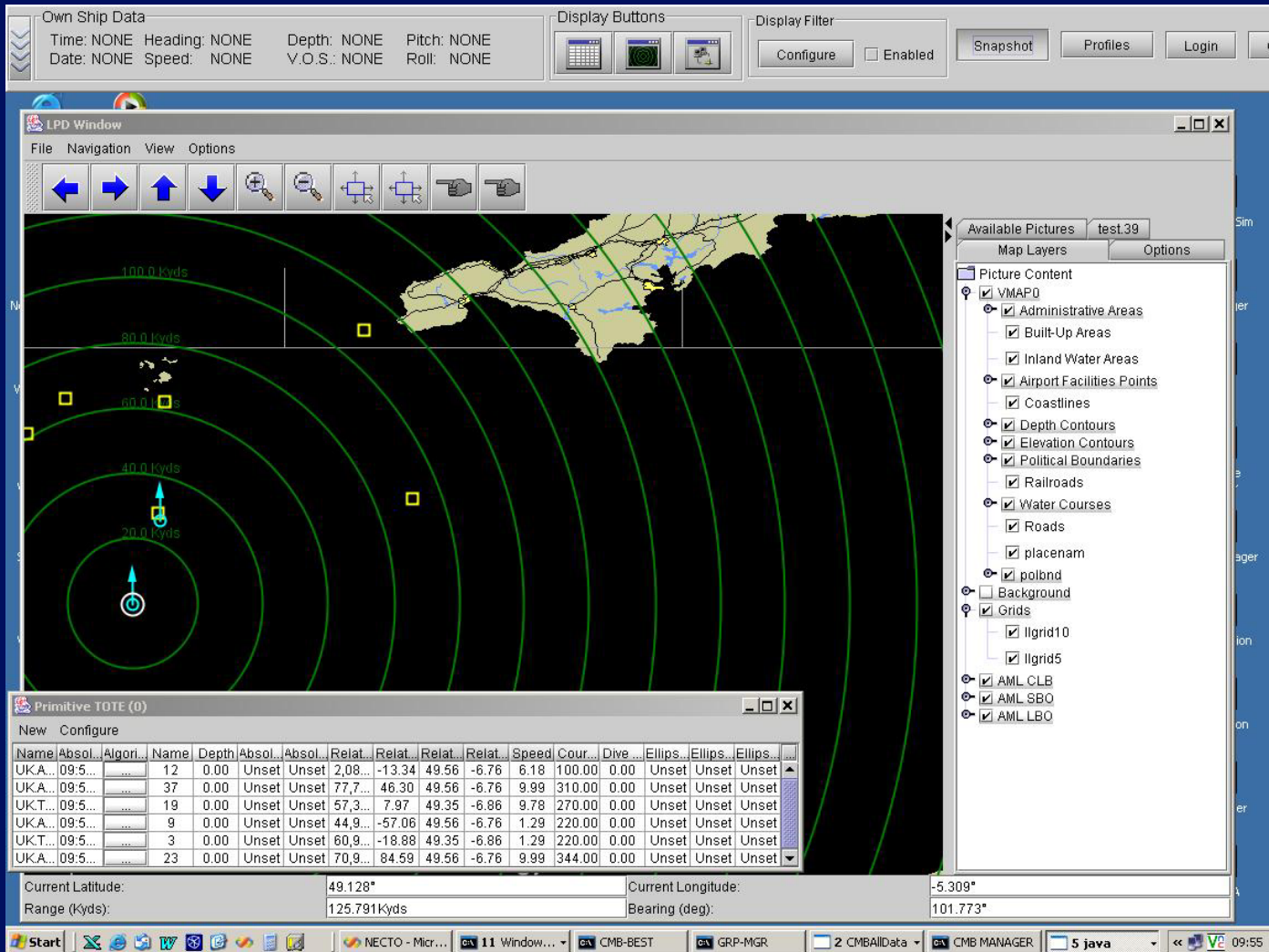
Virtual battle experiments

Storm trial JMC 043 Oct / Nov 04

DeRSCI

The End

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An Open Architecture Approach to NEC

[dstl]

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